US EPA Mid-Continent Ecology Division

Research Project Summary

Diagnosis of Impairment in Great Lakes Coastal Ecosystems: A Case Study of Lake Michigan's Muskegon and Grand Rivers

Overview

The Division's diagnostic research focuses on the need to determine causes of biological impairment within an integrated framework linking watersheds with receiving water bodies that support the Total Maximum Daily Load (TMDL) process and other regulatory programs. All stressors (nutrients, suspended and bedded sediments, toxic chemicals, and habitat alteration) will be considered under diagnostics research, though greater emphasis may be placed on an individual stressor, combinations of stressors, and/or modes of action according to the prevailing problems or issues of the aquatic ecosystem, watershed, or region as a whole. The starting point for diagnostic research is the report of biological impairment, nonattainment of aquatic life use, or other indications of adverse effects (e.g., toxicity). The endpoint for the diagnostic process is the identification of causes of impairment, including the allocation of observed effects among multiple stressors.

For toxicity in sediments, substantial progress has been made to date for a number of chemical classes and manipulations for whole sediments and sediment pore waters (Ankley and Schubauer-Berigan 1995, Ho et al. 1999, Burgess et al. 2000). With the successful development of solid-phase sediment Toxicity Identification Evaluation (TIE) methods, field validation of interstitial water and whole sediment TIE methods is needed. After development of the whole sediment and interstitial waters TIE methods, field validation of the methodologies are required to determine if the causes of toxicity identified by TIE represent the source of toxicity at the field site. Field validation will involve the TIE analysis of sediments with impaired benthic communities from both fresh and marine sites, and ideally, the causes of impairment for these sediments would not be some other stressor (e.g., suspended and bedded sediment or degraded habitat). Once a suspected toxicant is identified, field sediments and organisms would be analyzed. The final step in the validation process would be to reproduce the same community signature observed in the field, within laboratory-controlled situations by introducing the suspected toxicant into clean sediments in a mesocosm. The field validation effort will also allow the evaluation of benthic community signatures and toxicant relationships. If useful relationships can be developed, a library of chemical stressor-benthic community responses would be developed to complement relationships derived from toxicity databases above, and this library would be developed on a water body class scale. Field validation will also permit the evaluation of toxicant/stressor and biological indices relationships for benthic communities.

The diagnostic research component of the Implementation Plan considers State and Tribal monitoring and restoration programs, and links its research to addressing uncertainties, research needs, and desired research products associated with State and Tribal programs. The regional cases studies for demonstrating the diagnostics approach are developed to meet the following objectives:

1. develop diagnostic tools for single and multiple stressors;

2. develop forecasting models;

3. illustrate the application of diagnostic methods, tools, and models for single and multiple stressors, including forecasting models;

4. provide input to regional decision-support systems;

5. demonstrate how assessment results can be extrapolated across regions, watersheds, water bodies, and biological levels of organization; and

6. illustrate how stressor-response relationships vary among different classes of systems in a predictable fashion.

The Muskegon and Grand Rivers of Michigan span nutrient enrichment, sediment loading, toxic contamination, and habitat loss gradients representative of those found throughout the Lake Michigan basin. We will assess the responses of fish, macroinvertebrate, and periphyton assemblages to these stressors. Field sites will be selected in headwaters streams, larger streams and rivers, coastal wetlands, and Lake Michigan at the mouths of these rivers to test stressor-response relationships within and among these aquatic resource classes, and across spatial scales ranging from headwater streams to the Lake Michigan basin. Working hypotheses for the Lake Michigan Diagnostics case study are:

H0: Fish, invertebrate, and algal assemblages will show no significant responses to nutrient enrichment, clean sediment loading, toxic contamination, and habitat loss.

H1: Fish, invertebrate, and algal assemblages will show significant negative responses to nutrient enrichment, clean sediment loading, toxic contamination, and habitat loss.

The stressor responses to these biological assemblages may be direct or indirect in nature and vary in magnitude across different spatial scales in each resource class. For example, fish assemblages may move great distances based on habitat and reproductive needs; therefore, the stressor response to fish may vary across a large spatial scale (headwaters to wetlands). Macroinvertebrate assemblages, on the other hand, usually respond to stressors on a much smaller spatial scale due to their limited mobility relative to fish assemblages.

Future directions will include the development of two kinds of models: 1) empirical models of stressor-response relationships that will be developed using multivariate analyses, and 2) models used to predict changes in biological responses with changes in single and/or multiple stressors.

Key Products

Illustrate the application of diagnostic methods, tools, and models for single and multiple stressors, including forecasting models.

Illustrate how stressor-response relationships vary among different classes of systems in a predictable fashion.

Provide input to regional decision-support systems.

Present results of study to local, regional, and national scientific meetings and conferences and publish results in a variey of peer-reviewed journals.

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